Optimizing the Robotics Closet

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1 Introduction

The Husky Robotics team is a team of both undergraduate and graduate students from UW building a Mars rover to compete in the University Rover Challenge. The rover must perform a variety of tasks, such as autonomous navigation, soil collection, and typing on a keyboard with a robotic arm. The team is divided into subsystems: Chassis, Arm, Science, Electronics, Software, and Manufacturing. The subsystems work independently but collaborate to create the robot. Given all these tasks and the relatively short amount of time given to build out the functionality, efficiency is key when it comes to the build process.

The robotics team has only a small closet in the Mechanical Engineering Building. The closet stores the robot along with all of the tools, electronics, sheet metal, carbon fiber, and plastics that go into building the robot. Each item belongs to one of the subsystems, and is usually stored near other items belonging to that subsystem. Unfortunately, the robotics closet is not particularly organized, and members often spend on the order of 10 minutes looking for the thing they needed. Our goal is to find a reorganization plan for the items in the closet such that expected duration of each closet visit is minimized and items belonging to the same subsystem are in the same connected component on the shelves.

The closet has two shelves, one on each side. One side stores items in uniformly-sized boxes while the other side has several other classes of items, such as soldering irons, and boxes of various sizes. The rover is stored in the middle of the room on a big cart. Behind it is the robotic arm and the science station. In the back are the sheet metal, various metallic cylinders, wood, and rolls of carbon fiber. By examining the frequencies of retrieval by each team and treating the closet as a grid, we should be able to produce a better layout of the closet.

The robotics closet before optimization.

2 Related Work

Deepesh Singh's *A Beginner's guide to Shelf Space Optimization using Linear Programming* explains an integer programming formulation for finding the optimal layout of a store that maximizes sales. The guide organizes the store into several racks, each with a certain number of shelves. One key assumption is that only one product can fit on a rack. The model uses a table showing how many sales are generated by each item depending on which rack it is placed. The objective function is then the profit generated by a given arrangement. Arrangements are represented by a matrix, with each a_{ij} representing whether product j is on shelf i. If it is, the a_{ij} is 1 and 0 otherwise. The guide shows how to maximize this profit function. Although this approach is a good start, our problem differs in several ways: we can fit more than one box on each shelf, and our goal is to minimize time of retrieval rather than maximize profits.

TODO: More related work

3 Model